FRACTURES OF THE OS CALCIS AND ASTRAGALUS.

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We have been led to undertake this study, because during the last few years many cases have come to our notice in which a failure to accurately diagnose the condition has led to results certainly less good than might have been obtained by better directed methods. At the outset of the investigation we supposed these fractures to be uncommon, but this opinion we have been obliged to change and now incline to the view that they are more common than has been generally supposed.

Our deductions are based upon the study of 111 cases admitted to the Massachusetts Hospital during the last fifteen years. In many cases the notes are not sufficiently accurate to permit conclusions to be drawn upon many of the minor points, and we have confined ourselves in most instances to the discussion only of those cases in which we have personally studied the X-ray plates or been able to examine the patient a considerable time after the injury.

Etiology.—Age, occupation, and sex: As might be expected the occurrence of these fractures follows the rule common to all severe fractures, that they occur more frequently in those whose age and occupation expose them to external violence. Thus no fractures in this series occurred in children, very few in women, the vast majority in men in the prime of life.

Frequency: No method of estimating the frequency with which any fracture occurs is wholly satisfactory, as the situation of the observer, the class of population with which he has to deal, and entirely accidental causes, influence the number very greatly. It may, however, be of interest to note that during the last eleven years there have been in the hospital 83 cases of fractures of astragalus and os calcis, 204 cases of Potts' fracture and 396 cases of fracture of the femur.

Method of Production: To decide by exactly what mechanism these fractures are produced, is a matter of more than ordinary difficulty, for the various factors entering into the question are many and it is practically impossible accurately to estimate the value which should be given to each. The problem differs materially from that in fractures of long bones or bones not situated in such immediate proximity to many complicated joints. It would obviously be important, were it possible, to know the exact position of the foot at the moment the force was applied. Thus, theoretically at least, the amount of extension, the presence of inversion or eversion, the condition in regard to tonicity of the various muscles acting upon the foot, and the strength of certain ligaments, must be known if we are to arrive at a correct estimate of these various factors. While much ingenuity has been expended in the attempt to give to these factors their correct importance, it does not seem to us, with the data at hand, possible to apportion their value with sufficient accuracy to yield valuable results. It is, however, entirely possible, and quite important, to note in general how these accidents occur.

Fractures of the Os Calcis: These fractures are in the great majority of cases true compression fractures, and are generally due to a fall from a height on to a hard substance, as the ground or the floor of a building. The bone is crushed between the astragalus above and the ground or floor beneath, the astragalus being protected from the direct force of the blow by its situation between the two malleoli, and probably also by the crescentic contour of its upper surface, which tends to distribute the force of the blow. Some of the observations upon this point by our Continental brethren are not without their humorous aspect. One gentleman, for instance, gravely assures us that if a man falls from a height of fifteen or eighteen feet onto a stone floor, the os calcis will be broken, provided, always, that the floor does not give way. The bone may also be broken by direct violence, as in the case of one patient, whose heel was caught between the curb-stone and the wheel of a wagon; or by weights falling upon the foot so as to strike upon the side. These are not, however, common methods of production. In our series there are sixty-three cases in which the nature of the accident is described. Of these, fifty-nine were due to falls from a height, and four only were produced by direct violence.

Astragalus: As we have already suggested, the protected position of this bone makes it less likely to be broken by crushing strains, but it is nevertheless frequently fractured in this way. Thus Hamilton,[1] in ten cases, found that nine were due to falls from a height, and Gaupp,[2] in sixty-one cases, found that forty-five were produced in this way. In our series the method of production was known in thirty-five cases. Of these, twenty-one were due to falls from a height and fourteen to direct violence, (see Fig. 20). This appears to be a considerably larger proportion than that noted by most previous observers, but the series presented by Hamilton is too small to warrant accurate deductions, and our series is sufficiently limited, so that the proportion of three to two is likely to err considerably in either direction. It is important to note, however, that the proportion of the fractures of this bone due to direct violence is much greater than that of the os calcis.

Pathology.—Our knowledge of the pathology of these fractures must be derived largely from the study of X-ray plates, as the number of cases in which the accident is fatal—and it is possible to study the exact conditions at autopsy—is very limited and the position of the bones is such that little reliance can be placed upon inferences drawn from examination with the fingers. It is perhaps not too much to say that most of the errors occurring in diagnosis result from too much dependence being placed upon methods of examination other than the X-ray. It would be an endless task to attempt to describe all the possible fractures of these bones, and we have not ourselves felt competent to decide, even from a careful study of an excellent series of X-ray pictures, the exact details of the fracture in many cases. Certain general types of fractures, however, can be distinguished, and we have made our classification rather with a view to the possibilities of treatment than following the lines of previous observers.

Os Calcis: We have been able to distinguish three general types of fracture of this bone—(1) That in which the fracture has been confined largely to that portion of the os calcis lying behind a vertical plane through the middle of the body of the astragalus. These we have described as heel fragments. They may be further subdivided into (*a*) cases with one large heel fragment (see Figs. 2, 3 and 4), (*b*) cases of small heel fragments which practically correspond to the avulsion fractures of other authors (see Fig. 6), and (*c*) cases showing cracks or fissures in the portion of the bone above noted, which, had the injury been more severe, would have resulted in the breakage of heel fragments (see Figs. 7 and 8). (2) That in which the force of the blow has been expended upon that portion of the os calcis lying beneath the astragalus, in front of above plane—in other words, roughly, the anterior half of the bone. These we have described as comminution of the anterior half, as in our series all the cases show comminution (see Figs. 10 and 11). (3) In this class we have placed those cases in which the whole os calcis is crushed and converted into what might be described as a bag of bones, the fragments being held together, apparently, only by the shreds of periosteum and by the surrounding soft parts. The bone is literally shattered. These cases we have described as completely comminuted (see Figs. 12 and 13).

In only nineteen cases have the X-ray plates been sufficiently perfect so that accurate deductions could be drawn. Of these, Class 1 (heel fragments) contains eight cases; Class 2 (the cases of the anterior comminution) contains five cases;

Class 3 (the completely comminuted cases) contains six. From this it appears that Class 1 is slightly more common than either of the other classes, but the difference is not sufficiently great to justify conclusions.

As fracture of the sustentaculum tali has been frequently mentioned by other observers, it would be improper to pass it without mention. It belongs, however, to the anatomical rather than to the clinical method of classification, and while it is by no means improbable that such fractures might take place even without other damage to the bone, we have seen no cases in which this has occurred as a distinct type. In many of the cases—notably, those in Class 3—there is undoubtedly fracture of this process, but as it is only an incident of the whole injury and not in itself important, we have not been inclined to give it prominence. Our study of the X-ray plates makes us doubtful whether we could distinguish such a fracture if it occurred, and to identify it by any other name is to depend upon mere guess work.

Astragalus: The classification of fractures of the astragalus is much more simple than those of the os calcis. The position of the bone is such that it has a protected part and an exposed part; the body being largely protected by its position between the malleoli, and the neck, exposed particularly to violence giving a twisting strain, or to crushing blows falling in front of the body.

1. Fractures of the Neck.—This is much the most common fracture of the astragalus (see Figs. 18, 19 and 20). Gaupp, in forty-nine cases, saw it eighteen times, and in our series it occurred in ten out of fifteen cases in which the plates were satisfactory. Of these cases, five were due to falls; five due to direct violence.

2. Fractures of the Body.—This fracture is due to a crushing force similar to that which results in fracture of the os calcis, sometimes occurring with the latter, and it is difficult to decide what factors influence its production. The variety of fractures is very considerable, varying from two large fragments to complete comminution of this portion of the bone.

It has not, however, seemed to us that a more minute classification was important from the point of view of treatment. In our series of fifteen cases it occurred five times, always from falls (see Figs. 21 and 22).

Os Trigonum[3]: No discussion of fractures of the astragalus is to-day complete without some reference to this curious little bone, which is sometimes attached to the astragalus as a process, on its posterior aspect, sometimes entirely detached, and joined only by a cartilaginous union, sometimes partially fused, showing that it had previously been detached. Its importance lies largely in the fact that when displaced upwards as a result of injury to the foot, it is frequently described, from an examination of the X-ray plates, as a fracture, and it is always wise to bear the fact of its occurrence in mind and not be misled by the appearance of an apparently isolated fragment just behind the posterior border of the astragalus (see Fig. 17).

Diagnosis.—An extended discussion of the methods of diagnosis in fractures of these bones would be out of place here, as they differ in no essentials from those applied to fractures elsewhere. We wish, however, particularly to draw attention to the fact that these methods have been so inaccurate as to prove conclusively that they are not to be depended upon. Thus, Ehret[4] in a series of forty-seven cases, found that only three had been correctly diagnosed immediately after the injury. In our series of sixty-six cases of fracture of the os calcis, a large majority of which came directly to the hospital and were under the care of a skilled staff with most modern methods at their command, seven cases were wrongly diagnosed and as a result wrongly treated. Of these seven cases, two were hospital cases and five had been under the care of other practitioners; three were regarded as sprained ankles, one as a Potts' fracture, one as a dislocation, two apparently as simple bruises of the foot. As will later appear, the results of the treatment of these fractures are so bad that no method which will lead to their more accurate treatment should be neglected. The tenderness and swelling are such that even in the most skilled hands accurate diagnosis is entirely impossible except by means of the X-ray, and we believe that no case can be considered as having been properly diagnosed until a satisfactory X-ray plate has been examined.

In the case of the astragalus, in thirty-eight cases three were wrongly diagnosed—all of these by practitioners not connected with the staff. One was regarded as a contusion, one as a sprained ankle, one fell into the clutches of a "natural bone-setter," who failed to set the bone. All these cases were fractures of the neck, which theoretically should be easier to detect than fractures of the body of the astragalus or of the os calcis. The statement made above in regard to the use of the X-ray in fractures of the os calcis is equally true and its effect upon treatment is even more marked, as accurate diagnosis will enable the surgeon to decide exactly what condition he has to deal with and what measures must therefore be taken. This will be further discussed under "Treatment."

Prognosis.—We cannot better illustrate the probable outlook in these cases than by discussing the results which have actually been obtained in the cases under our observation. We have been much impressed by the fact that the majority of the results are not good as compared with most other fractures, and we have thought that in some cases, at least, somewhat better results might have been obtained by different methods of treatment.

The cases which we have used in this classification are only such as we have personally examined more than one year after the injury. Many of them were seen more than three years after injury, so that we believe we have obtained a fairly satisfactory view of the ultimate results. We have classified the results as "Good," "Fair," and "Bad," which terms we have defined as follows:

1. Good.—Those cases having a useful foot without pain, or at least without much pain. None of them are entirely

normal, and in the great majority there is marked limitation of lateral motion (see Figs. 4, 5 and 9). In our series at least, no case was seen with anything approaching a return to normal condition of the bones.

2. Fair.—Those cases in which the patient has been able to return to work and in which his earning capacity has been but slightly impaired, but in which pain, some disability, and the necessity for wearing pads, plates, or other form of apparatus, have been present (see Fig. 3).

3. Bad.—Those cases in which there is marked disability and the earning capacity has been distinctly diminished (see Fig. 16).

Os Calcis: We have been able to examine twenty-six cases in which the end result of the injury was known and the patient personally seen more than one year after injury.

These showed: Good result, 13, or 50 per cent.; fair result, 10, or 38 per cent.; bad result, 3, or 12 per cent.

Examining these cases more closely, with a view to determining what type of fracture gave the best result, the X-ray plates have been sufficiently satisfactory in twelve cases. Of these, seven were classified as "heel fragment" cases, and of these 5 were good, 1 fair, 1 bad.

Five cases were classified as "comminuted." Of these, none were good, 4 fair, 1 bad.

It seems, therefore, just to conclude that the cases classified as "heel fragment" cases show a better end result than the cases with much comminution.

Astragalus: We have been able to see and examine eight cases of fracture of the astragalus. These showed: Good result, 2, or 25 per cent.; bad result, 6, or 75 per cent.

From such a small series it did not seem possible to determine what type of fracture was the most favorable. It did, however, appear that cases with a fracture of the neck did not always give bad results, and that the amount of displacement between the body and the neck was, as would be expected, the most important element in permanent disability. It is very obvious from the results that this fracture gives a result distinctly worse than fracture of the os calcis.

Duration of Disability.—Since, at the present time, many of these cases become the subjects of litigation, it is important to inquire in regard to the duration of disability.

Os Calcis: The duration of disability was known in twenty cases of fracture of the os calcis. Of these, 14 were disabled not in excess of six months; 1, from six months to a year; 3, from a year to a year and a-half; 2, from a year and a-half to two years. The average duration of disability was somewhat in excess of six months.

Astragalus: The duration of disability was known in nine cases of fracture of the astragalus. Of these, in 1 it was not in excess of six months; in 2 it lasted from six months to a year; in 2, from a year to a year and a-half; in 1, from a year and a-half to two years; in 3, over two years.

The average disability was about a year and a-half. From this it will be clearly seen that the duration of disability in fractures of the astragalus is much in excess of that in fractures of the os calcis, and the probable duration of disability will be an important factor in estimating the appropriate compensation for damage in these cases.

Other Factors Influencing Prognosis.—In examining these cases we have been struck by the frequency with which marked thickening is found in the region of the external malleolus and by the fact that it is the point to which many of them refer most of their pain. Thus, out of eighteen cases of fracture of the os calcis, in which our notes are complete on this point, we find that in twelve there was marked thickening in the region of the external malleolus (see Fig. 15), and in only three was the thickening marked beneath the internal malleolus. Gaupp ascribes this thickening to the forcing of fragments outward, because the foot is more or less inverted at the time of the injury. It seems to us more reasonable to suppose it to be due to the anatomical arrangement of the bones, by which the force, transmitted directly downward, will be somewhat broken on the inner side by the anatomical position of the neck of the astragalus and its tendency to give, whereas, upon the outer side the force is exerted directly upon the body of the astragalus and transmitted to the os calcis. It may also be suggested that the lower position of the external malleolus and the smaller size of the depression on the outer side of the ankle make the fragments thus placed a greater source of obstruction to motion. In many cases the arrangement of the thickening is such as to suggest that the tip of the external malleolus was practically embedded in new-formed bone, and that there was an attempt at the formation of a false joint in this position, with accompanying pressure and pain. In one case, at least, removal of the overgrowth of bone in this position produced marked improvement in the symptoms and the foot was transformed from a bad to a good result (Fig. 16). We believe that more attention should be paid to this point and that more frequent resort to surgical intervention after the disability is fully developed will result in considerable improvement in many cases.

Compound Fractures.—As might be expected, the cases of compound fracture show a long period of disability. Infection is common, and complicated, as it is, by the proximity of many joints, makes it proper to classify this injury as a very serious one. In not a few reported cases amputation has ultimately been necessary and in most cases repeated operation only has resulted in cure.

Treatment.—Treatment may be divided into that applicable to fresh cases, and a discussion of what may be done to remedy the disability caused by old fractures which have either been improperly treated or in which serious disability has resulted in spite of the best of care.

Treatment of Fresh Cases.—The general principles of treatment do not essentially differ from those applicable to other fractures in this region. The foot should be elevated, and during the stage of acute swelling can be put up in a " pillow " splint or posterior wire splint in such a way that the bandages can be readily removed, the condition of the soft parts inspected, and ice-bags applied if necessary. Where the skin is threatened by a loose fragment, it must be carefully watched with a view to replacing or removing the fragment by operation before the vitality of the skin is too much lowered. After the swelling has considerably diminished—generally at the end of a week or ten days—an attempt may be made to improve the position if loose fragments are present. In impacted cases little but damage is likely to be done by manipulation, unless undertaken as the result of indications clearly shown in the X-ray plate, and by methods to be discussed in detail later. Except for the retention in position of loose fragments, and after operative interference, there is little necessity for immobilization in these cases, and the slavish adherence to this principle of the treatment of fractures is likely to increase rather than diminish the disability. In impacted cases, early massage and passive motion are to be strongly advised, though of course care must be taken to see that loosely-impacted fragments are not disturbed. The most common and serious error in treatment is to allow the patient to bear his weight upon the foot too early. We are entirely in accord with the opinion expressed by Nasse and Borchardt[5] that these cases should bear no weight on the foot for at least sixty days. It is abundantly evident that the amount of callus in many cases is excessive and is an important cause of disability, and it seems reasonable to suppose that the amount of callus will be considerably increased by early use of the foot. On the other hand, massage and passive motion, by tending to preserve free movement in all the joints and prevent unnecessary adhesions, will have a marked effect in diminishing the disability. After the union is firm—that is, after a lapse of about sixty days—the use of the Zander apparatus as a supplement to passive motion is of undoubted benefit. There remain, however, a considerable number of special considerations, based upon a thorough understanding of the nature of the fracture, which will influence the surgeon in the treatment to be adopted, and which must be considered in detail.

FRACTURES OF THE ASTRAGALUS.

Fractures of the neck.—1. Cases in which the anterior fragment, consisting generally of the head and neck, is more or less dislocated and threatens the skin, require prompt treatment. It is occasionally possible to reduce the dislocated fragment and free the skin from dangerous pressure. Where this can be done it may be satisfactory, but in many cases the reduction will be only partial, sufficient, indeed, to relieve the immediate danger of the skin, but entirely insufficient to lead to a good after-result. Where reduction is possible they come into the class to be considered in the next heading. Where reduction cannot be achieved, or where the vitality of the skin has been seriously compromised, immediate operation is to be advised. This should consist in a free, curved incision over the front and outer side of the ankle joint, which will give good access to the fragments. The annular ligament should be divided and tendons retracted to an extent sufficient to give thoroughly good access. If the anterior fragment is sufficiently shattered and torn from its attachments to seriously compromise its vitality, a better result will probably be obtained by its complete removal than by an attempt to restore it to an approximately normal position. If, on the other hand, the principal fragment is large and its blood-supply probably good, it may be replaced in its proper position and held either by suture or wiring. The number of cases in which replacement with suture has been attempted is too small to warrant conclusions, and, though it is an ideal method of treatment, it is proper to admit that excellent results are obtained after complete removal of the head and neck of the bone, and that the danger of bone necrosis, with or without infection, is much less.

It is unnecessary to add that such an operation must be attempted only under the very best conditions and with the strictest attention to asepsis.

2. *Fractures of the Neck with Rotation of the Posterior Fragment.*—This class is quite similar to the one just considered, except that as the skin is not threatened there is no indication for immediate intervention, and operation should not be undertaken until the swelling has subsided and the tissues are in a better condition. Reference to the illustrations will show, better than any description, the reasons for operation in these cases (Fig. 19). The results without operation are nearly uniformly bad. Great limitation of the ankle joint is the rule and is not likely to be exceeded by that resulting from operative failure. In short, it is hardly probable that the ultimate condition will be made worse, and there is the best reason for supposing that it will be greatly improved.

The end to be sought by operation is the restoration of the fragments to their previous position. The difficulty lies in the rather insufficient exposure by any incision at our command, and the difficulty of rotating the body or posterior fragment into a normal position and then holding it in contact with the anterior fragment. If this can be done in a reasonably satisfactory way it is to be preferred to the alternative of removing the anterior fragment, but the latter procedure has given excellent results. The choice between these two operations can probably not be made until the joint is freely opened and the position and motility of the parts have been accurately determined. The importance of operation can be determined by a critical examination of the X-ray plate, but not the exact operation which will give the best results.

3. *Fractures of the Body.*—Fractures of the body of the astragalus are commonly impacted and frequently complicated by impaction of the underlying portion of the os calcis (Fig. 22). Though the ultimate result is likely to be bad, and much loss of motion at the ankle joint frequently results, it does not

appear that operation is likely to improve the condition. In some cases, however, the fracture is not impacted, or, at least, is partially impacted, being complicated by loose fragments, particularly from the anterior portion of the body. These fragments are particularly likely to become fixed in such a position as to prevent dorsal flexion, and when such fragments exist their removal is indicated. It is, however, by no means easy to determine the looseness of such fragments, or, indeed, to definitely state their origin. In one of our cases a fragment lying in front of the body of the astragalus was removed, and was thought to have come from that bone, but a study of plates leaves us in considerable doubt as to its origin.

OS CALCIS.

1. *Small Loose Heel Fragments* (*the Avulsion Fracture*).—These cases, which may be typified by Fig. 6, are best treated by operation. If left to nature, the convalescence is slow and a troublesome prominence over the heel is practically certain to result. The fragment is readily exposed by a curved incision and may be held in position by a nail or by suture or wiring, as suggested by Eisendrath.[6] The simplicity of the operation and the practical certainty of a good result, if skilfully carried out, seem to make the indication clear.

Large Heel Fragments.—These cases open an interesting field for discussion of possible benefit which may result from active treatment. When treated expectantly the results are frequently far from satisfactory. The upward displacement of the heel fragment generally results in troublesome "flat foot," and it is certainly possible that the condition may be improved by an attempt to improve the position. Carless[7] has suggested the possibility of pulling down the fragment into its proper position, or even over-correcting the deformity after division of the tendo Achillis. We have ourselves in one case done this without knowledge of previous work, and the result has been sufficiently favorable to encourage us to make a further attempt in this direction. In this instance, after subcutaneous tenotomy of the tendo Achillis, a large posterior fragment, which was partially impacted, was loosened, though with some difficulty, and its position apparently improved. The ultimate result has been considerably better than in most of the similar cases which we have seen. The difficulty in improving the position in this case came from inability to get a firm grip upon the heel fragment. This could be readily done by drilling two small holes on the sides of the heel fragment and inserting powerful hooks, such as those used by Porter,[8] in elevating the head of the bone after fracture and dislocation of the head of the humerus. With this addition to the technic there seems to be no doubt that the fragment could be broken loose from its impaction and placed in an improved position. It would probably be wise to over-correct the deformity and make the arch of exaggerated height on account of the tendency of these fragments to work upward as the swelling goes down beneath the plaster. A snugly-fitting plaster-of-paris dressing seems the most appropriate method of retaining position in these cases. While our experience is entirely too limited to warrant the assertion that such a method is to be unhesitatingly advised, we feel that further research in this direction is much to be desired.

2. *Fissures—Comminution of the Anterior Half—Complete Comminution.*—In the treatment of fresh cases of these varieties it does not appear that anything but expectant treatment is justifiable. In case of fissure a good result is generally to be had by this method. In comminutions of the anterior half the resulting disability comes from flattening of the arch and from the lateral displacement of fragments, particularly to the outer side, which interfere with the lateral motions of the foot and cause pain. It is possible to improve somewhat the flattening of the arch by padding under a plaster bandage, and this should always be attempted. In the early stages it is impossible to estimate how much trouble the lateral fragments will cause, and active intervention is therefore best postponed

until union has taken place and any indication for interference can be more accurately mapped out. In the case of complete comminution the same reasons make it unwise to interfere, except for the relief of resulting disability.

Old Cases.—The surgeon is frequently called upon to decide what can be done to improve the results of old fractures, either of the astragalus or os calcis, which have either been wrongly diagnosed, improperly treated—particularly by too early use—or which have followed the most conscientious treatment. The chief complaints are of limitation of motion, pain, or faulty positions of the foot, with displacement of the normal weight-bearing line. Many of these cases can be improved, and we are inclined to feel that the tendency has been to over-conservatism, and that greater willingness to attempt operative relief will be followed by good results.

Old Fractures of the Astragalus.—In these cases there are two prominent indications for operation:

(1) Limitation of motion: This frequently follows fracture of the neck of the astragalus with faulty union, as shown in Fig. 20. Motion is likely to be very much limited, and may be practically nil. The two operations to be considered are partial, or complete, astragalectomy. In the partial operation only the head and neck of the bone are removed, and this is particularly applicable to cases of faulty union due to rotation of the posterior fragment. The resulting improvement in motion in these cases has been very encouraging. Where the disability is great, and removal of the anterior fragment does not relieve the condition (a situation particularly likely to occur where the body of the bone has been broken), complete astragalectomy should be seriously considered. The possibility of a worse result is not large and very great improvement has followed in some of the cases in which this has been done.

2. Cases of Valgus or Varus Deformity: Cases of fracture of the astragalus are particularly liable to the worst varieties of

pronated " flat foot." This is well illustrated by the case shown in Fig. 23. In this case, as in other similar ones, the amount of motion at the ankle joint was sufficiently good to make it improbable that it could be improved by operation. On the other hand, very great disability resulted from the position of the foot, and operation was indicated for the same reasons that it is to be advised in severe cases of rigid " flat foot." The operation most applicable is the osteotomy of Trendelenburg,[9] in which the tibia is divided with an osteotome from side to side just above its articular surface, the chisel being manipulated so as to leave a V-shaped gap. The fibula is then divided at a similar level and the whole foot carried inward until the weight-bearing line is normal. The operation has been frequently done by the orthopedic surgeons for " flat foot " and with excellent results, but it is important not to over-correct the deformity as, there is little or no tendency of the bones to return to their former position, and it is entirely possible to convert a valgus into a varus foot by over-correction. Extended discussion of this point does not seem necessary, as the problem is essentially that of " flat foot."

Fractures of the Os Calcis.—These fractures do not present an attractive field for late operative interference. In those cases, however, in which there is excessive callus formation below the external malleolus, resulting in a painful foot, considerable relief may be expected. Whether this pain is due to pressure upon nerve filaments or simply to pressure of the lower end of the fibula against the new-formed bone, we are unable to decide, but the indication for the removal of such offending masses of bone seems to us clear, though it cannot be expected to influence, to any great extent, the motions of the foot. In many of these cases, however, pain rather than limitation of motion is the cause of disability, and where this is the case operation is practically certain to result in improvement.

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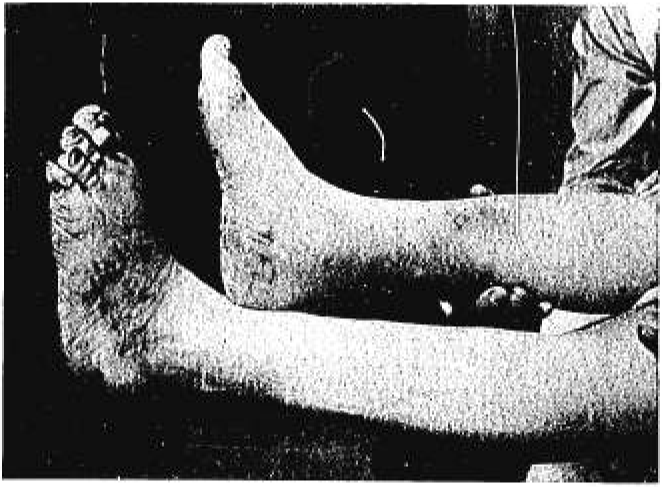

FIG. 1.—Fracture of the os calcis. This illustration shows well the amount of local swelling, the extent to which it is confined to the foot, and the lack of obvious deformity.

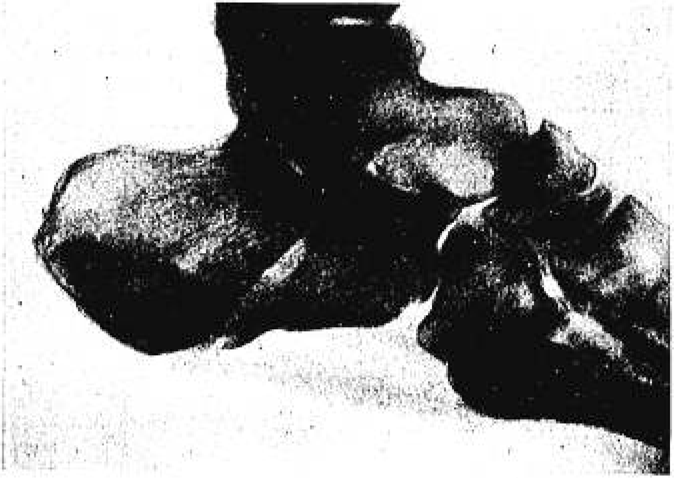

FIG. 2.—Fracture of the os calcis. Man, 40 years, fell ten feet, striking squarely upon both heels, on the ground.

X-ray shows fracture of the os calcis of the large heel fragment type.

This is a favorable case for tenotomy of the tendo Achillis and reduction of the posterior fragment, with restoration of the arch.

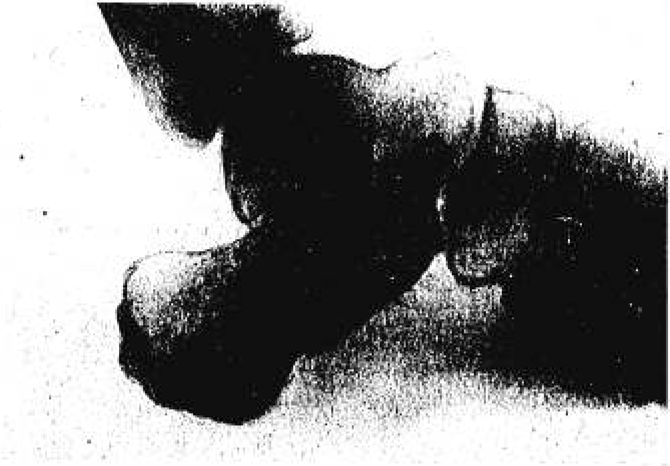

FIG. 3.—Fracture of the os calcis. This patient, a man, fell 15 feet on to frozen ground, striking upon both feet, in February, 1899. Right heel showed abnormal mobility and crepitus over the os calcis. X-ray shows comminuted fracture with large heel fragment. Treated with pillow splint; later, plaster of Paris bandage.

May, 1895. Has some pain through ankle joint. Always wears an insole. Is considerably hindered about his work. Examination, right foot: Considerable bony overgrowth beneath external malleolus. Motions: No flexion beyond right angle. No adduction. Very little abduction. Fair extension. Good position. Longitudinal arch, fair. Classed as fair result.

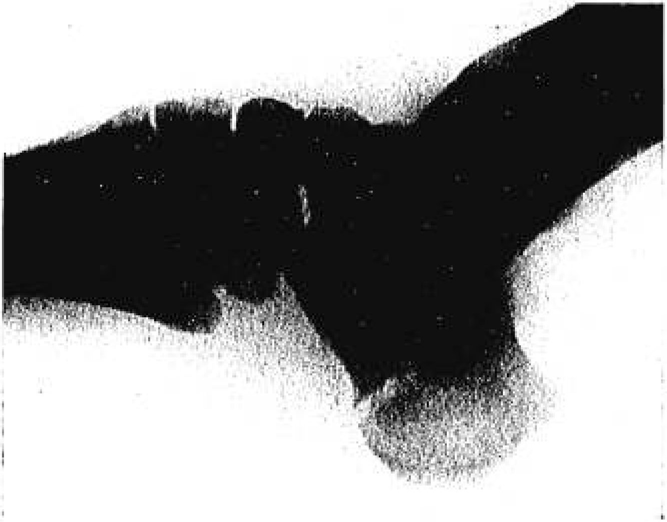

FIG. 4.—Fracture of the os calcis. Man, 26, fell from moving car, striking left foot against tie. In May, 1899, X-ray shows fracture of os calcis, large heel fragment type, with tendency of posterior fragment to be drawn upward. Plaster of Paris bandage.

June, 1905.—Reports returned to work after three and a half months. Very little trouble at any time. Foot becomes tired after long day's work. Present condition, slight fulness beneath external malleolus. Extension good. Flexion slightly limited. Very little lateral motion. No "flat foot." Classified as good result.

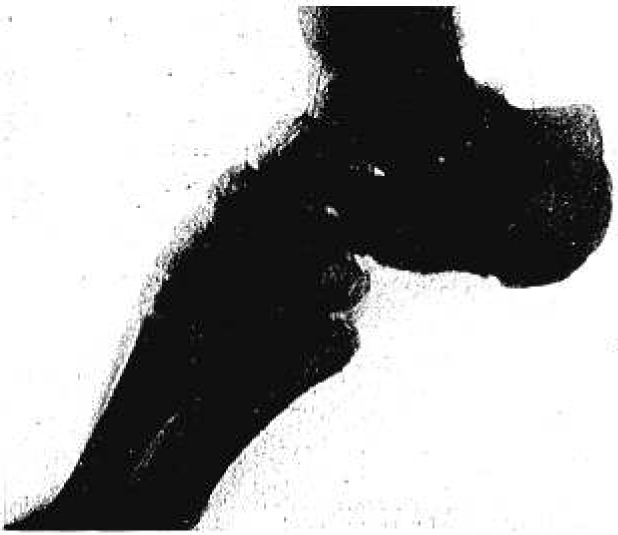

FIG. 5.—Fracture of the os calcis. Shows same foot as Fig. 4, six years after injury. Note great thickening of central portion of os calcis with fusion of astragalo-calcaneal joint.

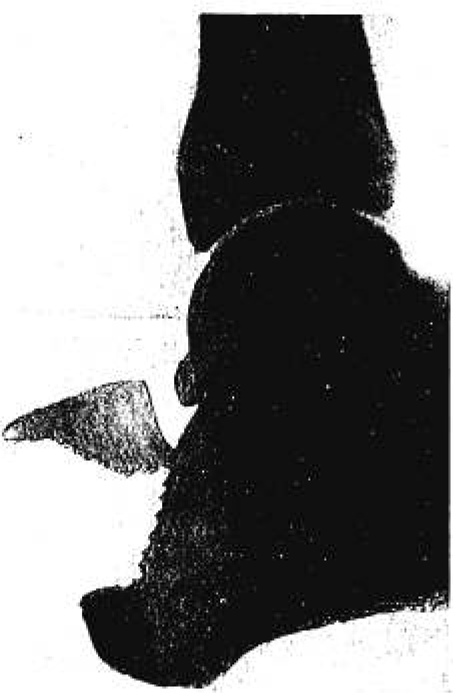

Fig. 6.—Fracture of the os calcis. A beautiful example of small heel fragment type of fracture—the avulsion fracture of other authors.

Fracture caused by slipping while getting on a street car, apparently by sudden contraction of muscles of calf. Operation refused. Result unknown.

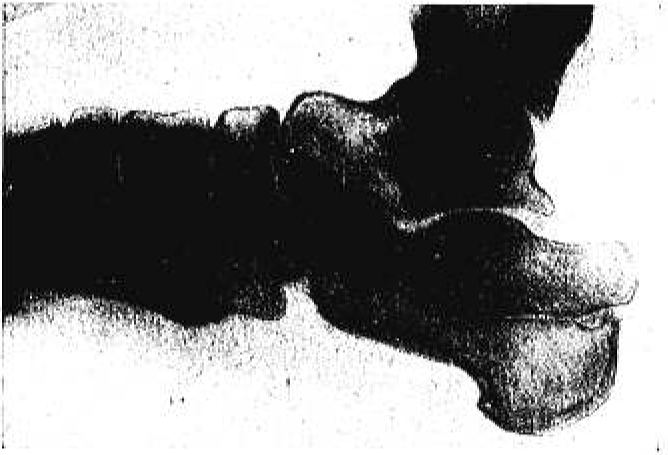

FIG. 7.—Fracture of the os calcis (left). Man, 44, fell ten feet to the ground, striking on both feet.

November, 1899. X-ray shows fracture of both ossa calcis of fissure type. Treated, plaster of Paris bandage.

May, 1905. Reports returned to work after six months. At first considerable pain in walking; now only in bad weather. Some soreness under instep, troublesome when climbing ladder. Examination of left foot showed practically no adduction or abduction. Flexion and extension good. Foot very flat and slightly pronated. Classified as fair result.

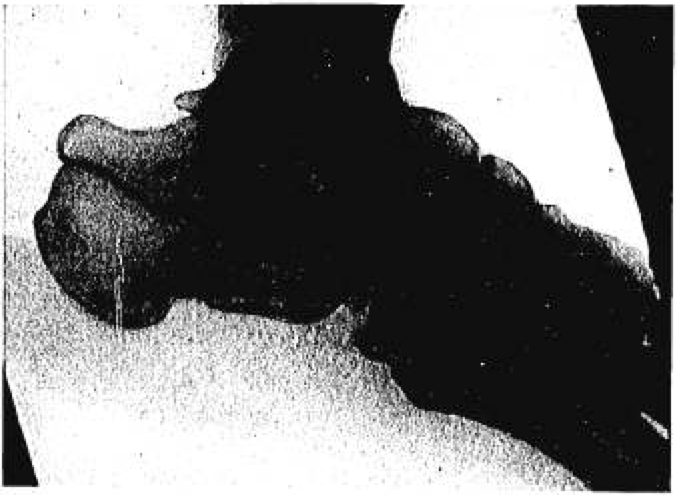

FIG. 8.—Fracture of the os calcis. X-ray shows right foot of patient whose left foot is illustrated in Fig. 7. Examination, May, 1905, showed some irregular thickening in front and below malleoli. All motions free. Considerable "flat foot." Weight-bearing line normal.

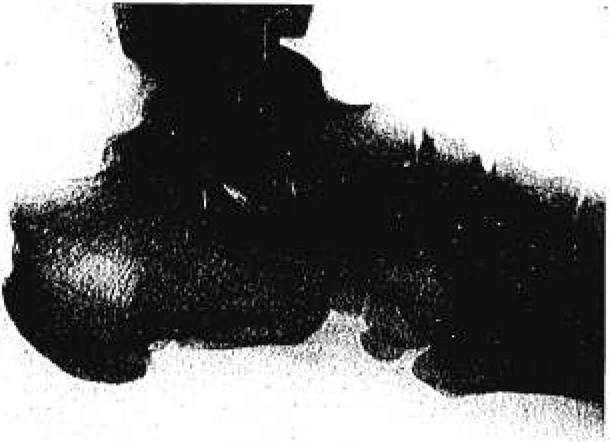

Fig. 9.—Fracture of the os calcis. Shows condition of right foot of patient described under Fig. 7, six years after injury. Note practical return to normal. Classified as good result.

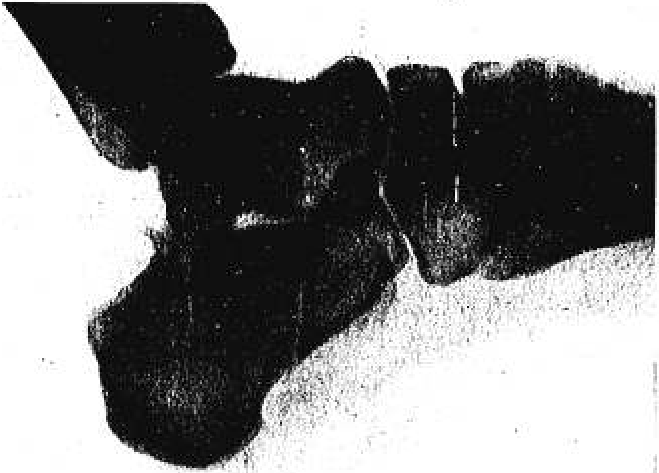

Fig. 10.—Fracture of the os calcis. Shows type of fracture described as comminution of anterior half of os calcis. Result unknown.

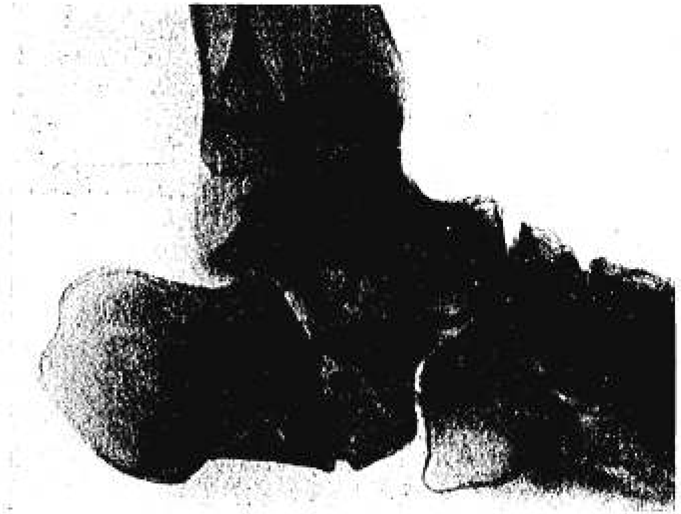

FIG. 11.—Fracture of the os calcis. Shows another type of comminuted fracture of the anterior half of the os calcis. Note great flattening of longitudinal arch. Result unknown.

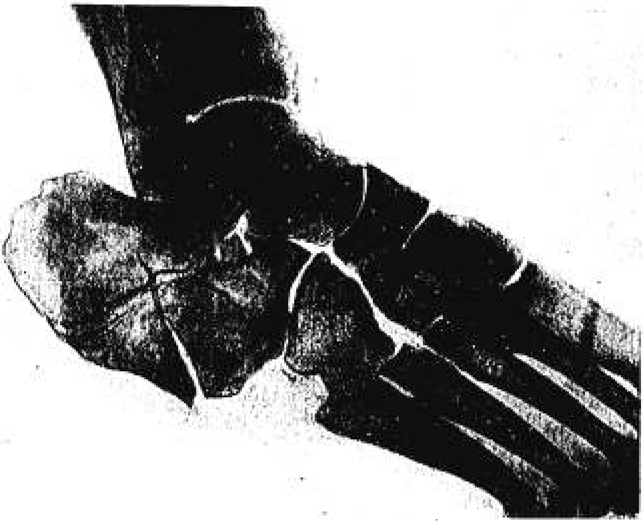

FIG. 12.—Fracture of the os calcis (right).

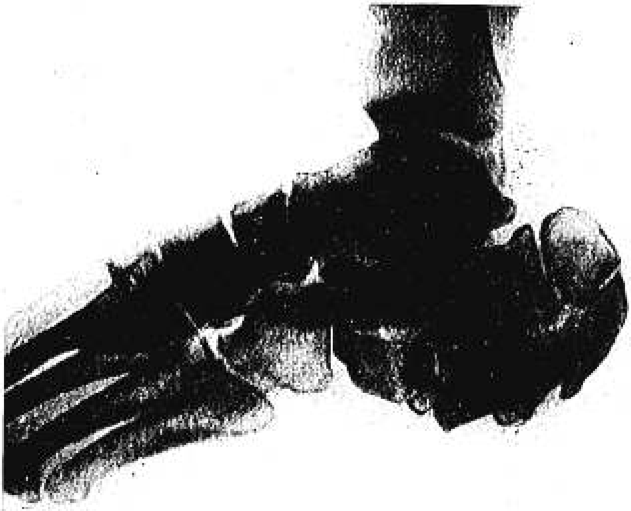

FIG. 13.—Fracture of os calcis (left). Figs. 12 and 13 show the injury resulting to a man of 26 who fell thirty feet to the ground, striking upon both feet. On the right side the injury was compound. They represent the worst type of comminuted fracture of the os calcis. Classified as "completely comminuted;" injury too recent to show result.

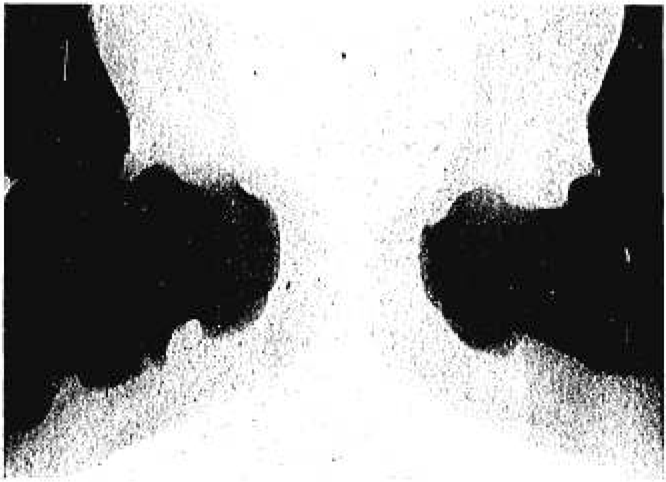

FIG. 14.—Fracture of both ossa calcis (lateral view).

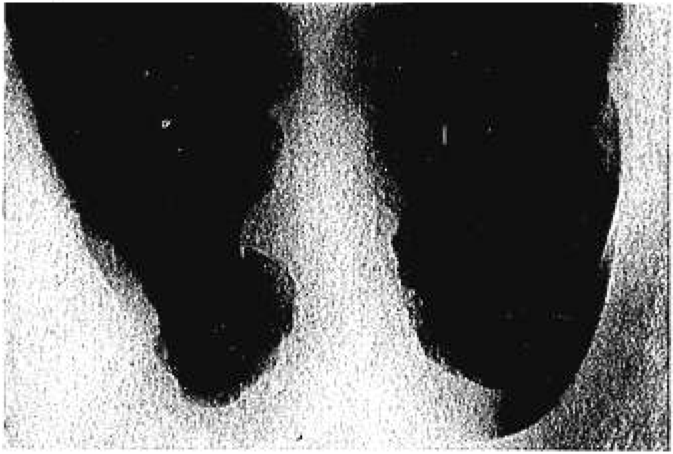

FIG. 15.—Fracture of ossa calcis. (Seen from above downward.) Figs. 14 and 15 show the condition six years after injury from fall of twenty feet on to concrete floor. In May, 1905, left foot shows much thickening below external malleolus. Longitudinal arch obliterated. Rigid pronated foot. Bad result. Right foot: Marked thickening to outer side of tendo Achillis. All motions good. Very little "flat foot." Good result.

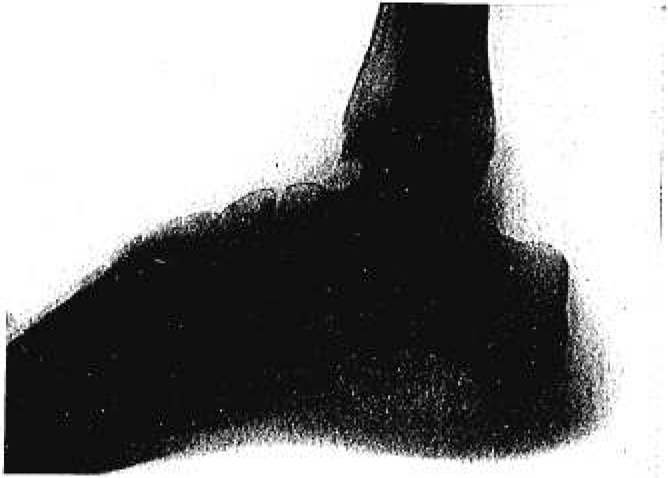

Fig. 16.—Fracture of os calcis. The astragalus is here driven down into os calcis, lowering ankle joint. Eight months after injury: painful foot, much thickening under external malleolus, no lateral motion, limited flexion and extension. Bad result. Operation by Dr. Goldthwaite. Removal of bony overgrowth beneath external malleolus. Now useful foot.

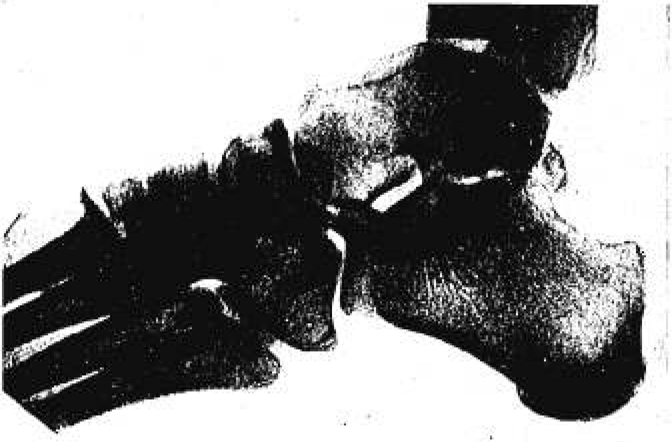

Fig. 17.—Os trigonum. In cases of injury this is frequently mistaken for a chip from the astragalus.

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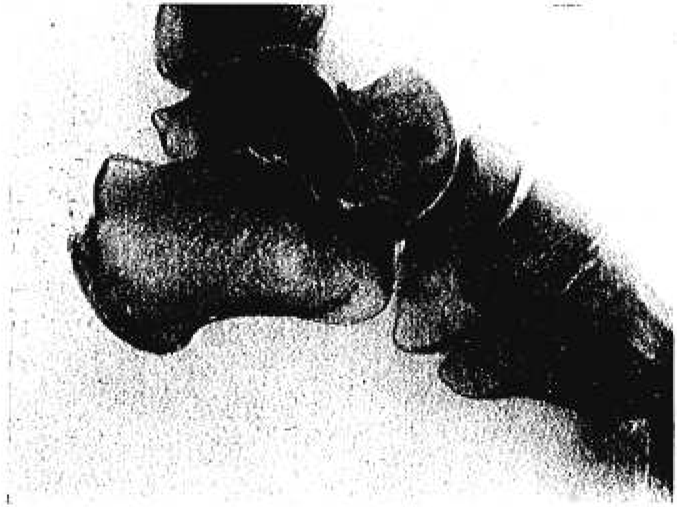

Fig. 18.—Fracture of the astragalus. Patient fell ten feet to ground, September, 1900. "Sprained ankle." X-ray, fracture of neck of right astragalus.

March, 1901. Bad result. Useless foot. Partial ankylosis. Partial astragalectomy, Dr. Brooks.

May, 1905. Foot slightly inverted, longitudinal arch raised, no lateral motion, no flexion, 10 degrees of extension. Painful foot. Bad result.

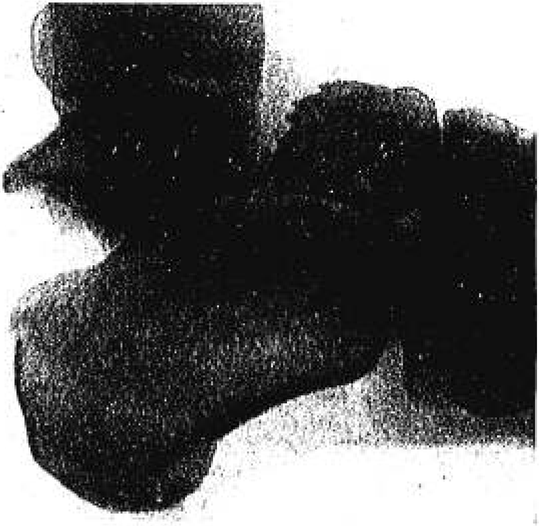

FIG. 19.—Fracture of astragalus. Fracture due to direct violence, from heavy bar falling on foot. May, 1904. Plaster of Paris bandage.

July 4. Trendelenburg osteotomy, Carney Hospital.

May, 1905. Painful foot. Forward displacement of foot on leg. Exaggerated longitudinal arch. Deformity not wholly corrected by operation. Marked inversion. Flexion good. Extension limited. Lateral motions limited. Bad result.

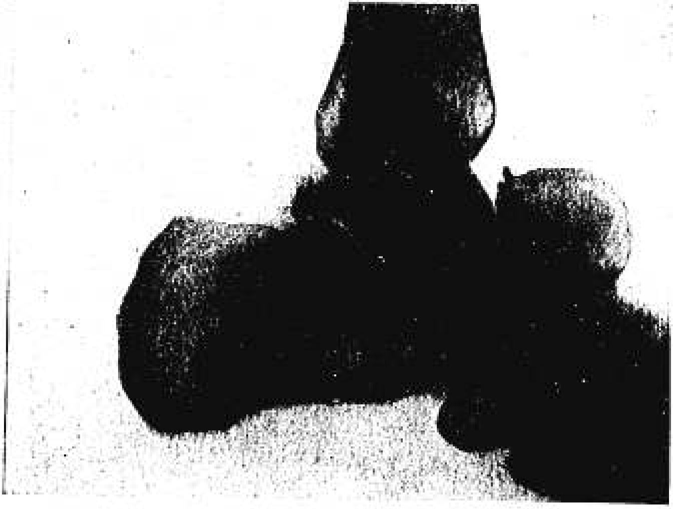

FIG. 20.—Fracture of astragalus. Foot run over by heavy team, February, 1902. Treated by natural bone setter. X-ray shows fracture of neck of astragalus. Operation advised and refused.

September, 1905. Painful foot. Much inversion, large bony fragment on dorsum (head of astragalus). Flexion fair. Extension poor. No lateral motion. Foot very flat. Bad result.

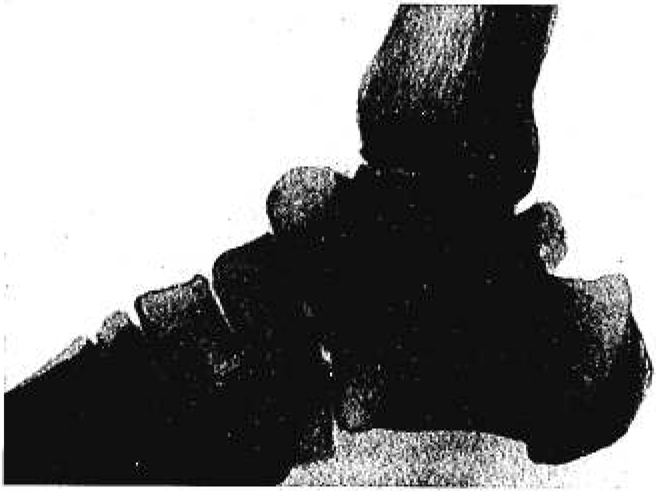

FIG. 21.—Fracture of astragalus. X-ray shows impaction of astragalus, especially in central portion, with lowering of ankle joint.

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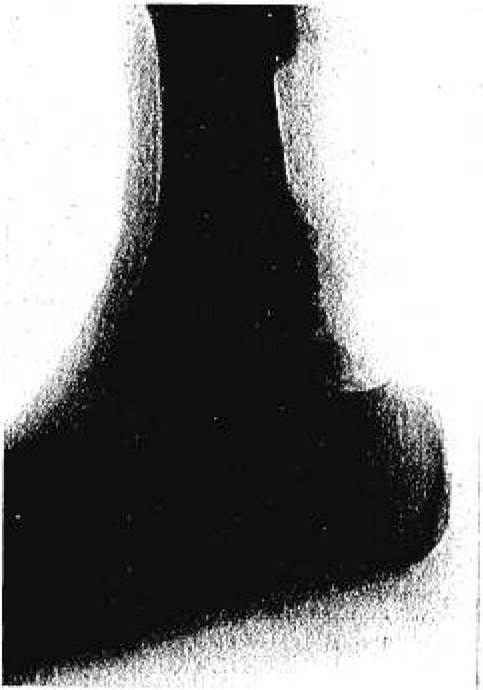

FIG. 22.—Fracture of astragalus. X-ray of right foot of patient shown in Figs. 23 and 24; impacted fracture of astragalus with lowering of ankle joint. Marked eversion.

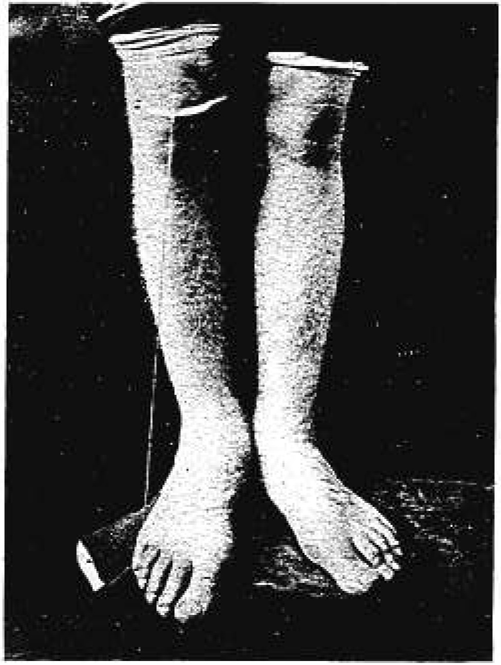

FIG. 23.—Fracture of astragalus. Note marked eversion with displacement of weight-bearing line, showing indications for Trendelenburg osteotomy.

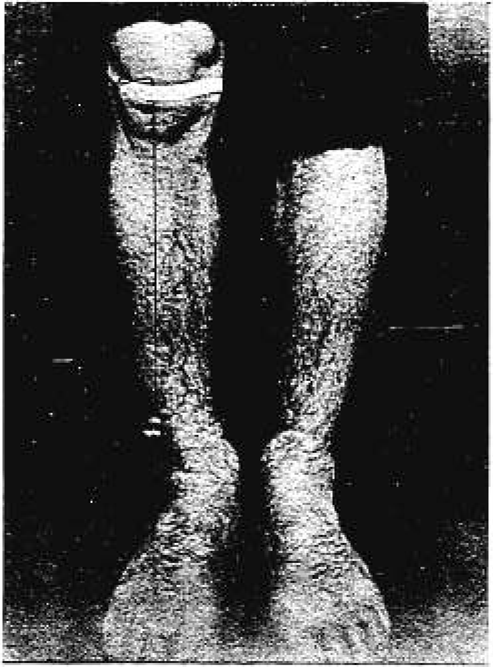

FIG. 24.—Same patient after osteotomy. Weight-bearing line partially restored. Foot converted from a poor to a good result. Now walks without discomfort or limp.